

This listing of claims will replace all prior versions, and listings, of claims in the application:

LISTING OF CLAIMS

1. (Currently amended) A ~~model of~~ system for modeling macrostructural characteristics of a bone ~~and interactions of the bone with external force~~ comprising ~~at least three orders of hierarchical structural and hierarchical mechanical properties of microstructure of the bone,~~ wherein:

a first hierarchical order ~~comprises~~ comprising at least one macroscopic region of the bone,

a second hierarchical order ~~comprises~~ comprising at least one empirically-derived nonhomogeneous second order component representing one or more osteons, trabeculae, or lamellae within the macroscopic region, and

a mechanical property correlated to each of the second order components,

~~a third order comprises at least one component representing one or more collagen bundles, hydroxyapatite crystallites, mucopolysaccharides, or combinations thereof,~~

~~each component is correlated with at least one mechanical property,~~

~~components of the third order are assembled to provide a description of components of the second order, and~~

~~components of~~ wherein the second order components are assembled ~~to provide a description of one or more characteristics of the first order, including at least one interaction with an external force~~ used to determine characteristics of the first order region, and

wherein a mechanical property of the first order region is determined based on the mechanical properties of the second order components.

2. (Currently amended) A ~~model~~ system as ~~defined~~ in claim 1, wherein the bone is compact bone or cancellous bone.

3. (Currently amended) A ~~model~~ system as ~~defined~~ in claim 1, wherein the mechanical ~~properties are~~ property is selected from the group consisting of tension, compression, shear, bending, torsion, prestress, pinching, and cement line slippage.

4. (Canceled)

5. (Canceled)

6. (Canceled)

7. (Canceled)

8. (Canceled)

9. (Canceled)

10. (New) A system as in claim 1, further comprising:

a third hierarchical order comprising at least one third order component representing one or more collagen bundles, hydroxyapatite crystallites, mucopolysaccharides, or combinations thereof corresponding to one or more regions of the second order components, wherein the third order components are used to determine characteristics of the second order components; and

a mechanical property correlated to each of the third order components, wherein the mechanical property of each of the second order components is determined based on the mechanical properties of the third order components.

11. (New) A system as in claim 10, wherein the collagen bundles are randomly distributed transversely to an orientation of at least one of the second order components.

12. (New) A system as in claim 1, wherein at least one of the second order components is anisotropic.

13. (New) A system as in claim 1, wherein:

an external force is applied to the macroscopic region of the bone; and

24. (New) A system as in claim 10, wherein a relative amount of the third order components depends on degree of calcification of the second order components.

25. (New) A system as in claim 24, wherein the degree of calcification of the second order components is assigned based on experimental determinations.

26. (New) A system as in claim 22, wherein distribution of alternate osteons, extinct lamellae, and bright lamellae depends on experimental determinations.

27. (New) A system as in claim 1, wherein the second order components comprise voids representing canaliculae, lacunae, or combinations thereof.

28. (New) A method of producing a model of a bone comprising the steps of:

- a) specifying a first order macroscopic region of a selected bone;
- b) dividing the macroscopic region into a finite number of elements, each element representing an empirically-derived nonhomogeneous second order component comprising one or more osteons, trabeculae, or lamellae;
- c) assigning a mechanical property to each second order component; and
- d) determining a mechanical property of the first order macroscopic region of the selected bone based on the mechanical properties of the second order components.

29. (New) A method of claim 28, further comprising:

dividing each second order component into a finite number of elements, each element representing a third order component comprising one or more collagen bundles, hydroxyapatite crystallites, mucopolysaccharides, or combinations thereof; and

assigning a mechanical property to each third order component, wherein the mechanical property of each of the second order components is assigned based on the mechanical properties of the third order components.

determining a change in the dimensions of each sample; and
determining a prestress in each sample based on the change in the dimensions of the samples.

41. (New) A method of claim 29, further comprising the step of modifying the mechanical properties of each of the second order components based on orientation directions of the third order components.

42. (New) A method of claim 41, wherein the orientation directions of the third order components are assigned based on experimental determinations.

43. (New) A method of claim 42, wherein the experimental determination further comprises the steps of:

selecting a subject bone of a specified type;
observing orientation directions of third order components of the subject bone;
determining orientation directions of the third order components of the selected bone based on the orientation directions of the third order components of the subject bone.

44. (New) A method of claim 41, wherein:
the second order components comprise alternate, extinct, and bright osteons, classified by their appearance in cross section under circularly polarized light;

the alternate osteons comprise extinct lamellae layered between bright lamellae,
the extinct osteons comprise extinct lamellae, and
wherein the method further comprises the steps of:

orienting the collagen bundles in each of the extinct lamellae by alternating layers of collagen bundles with orientation directions of about 82° and -82° with respect to the osteon axis, and

orienting the collagen bundles in bright lamellae in successive layers with orientation directions in sequence of about -61.5° , -41° , -20.5° , 0° , 20.5° , 41° , and 61.5° with respect to the osteon axis.

45. (New) A method of claim 29, further comprising the step of positioning the third order components randomly within a transverse plane of each of the second order components, wherein the transverse plane is positioned transverse to an axis of the corresponding second order component.

46. (New) A method of claim 29, further comprising the steps of:
assigning a force acting on the selected bone;
assigning boundary conditions for relative ability to move under loading to the third order components of the selected bone; and
computing deformation or fractures of the selected bone using the mechanical properties assigned to the third order components, the force acting on the selected bone, and the boundary conditions of the third order components of the selected bone.

47. (New) A method of claim 46, further comprising the step of determining fracture lines within the selected bone based on locations of cement lines that are formed between the second order components.

48. (New) A method of claim 46, wherein the boundary conditions of the third order components are assigned based on experimental determinations.

49. (New) A method of claim 46, wherein the boundary conditions of the third order components located at an interface between the second order components are each specified as having freedom of movement under loading.

50. (New) A method of claim 46, wherein the boundary conditions of at least one of the third order components are specified as having freedom of movement under loading.

51. (New) A method of claim 34, wherein the second order sample is an osteon.

52. (New) A method of claim 29, wherein a relative amount of the third order components depends on degree of calcification of the second order components.

53. (New) A method of claim 52, wherein the degree of calcification of the second order components is assigned based on experimental determinations.

54. (New) A method of claim 44, wherein distribution of alternate osteons, extinct lamellae, and bright lamellae depends on experimental determinations.

55. (New) A method of claim 28, wherein the second order components comprise voids representing canaliculae, lacunae, or combinations thereof.

56. (New) A method of claim 27, wherein the macroscopic region is represented by a three-dimensional image, which is divided to provide the finite elements.